Optimised Design Of Dual-Band Cellular Repeater At Different Frequency Bands (GSM 1800/ DCS, 3G)

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ABSTRACT: ***The intended application of our Cellular Repeater is a system of duplex reception, amplification and transmission used to enhance uplink(UL) and downlink(DL) signals in areas of low signal coverage i.e.; for the situations where signal quality between the base station and the receiver is poor and communication fails. This will be helpful for cellular providers to rectify the problems of poor signal service. This Dual band Cellular Repeater consists of Bidirectional amplifier, receiving and transmitting antennas. This paper discusses our assembling process, beginning with component selection and our difficulty in obtaining the required gain according to the user requirement in the process of testing. This cellular repeater can be operated in 2 different operating frequency bands namely, GSM 1800/DCS and 3G. The operation of the repeater can be switched between the two bands depending on the user requirement using a duplexer which provides proper switching among the bands. This model helps a lot in providing efficient signal service in the weaker coverage areas in the specified band of frequency.***

Index terms: Bi-Directional Amplifier (BDA), Yagi-Uda antenna, Patch panel antenna, power amplifier, GSM 1800/DCS, 3G

I. INTRODUCTION

A dual band cellular repeater helps the service provider to rectify the poor signal service. It can be operated in two different operational frequencies according to the user's convenience and requirement. This cellular repeater is economical as all the components used are of low cost and hence total cost has been integrated. It is user-friendly and eco-friendly. These are similar to the cellular broadcast towers used by the network providers for broadcasting, but are much smaller and are recommended to use for a particular building only. Modern cellular repeater amplifiers rebroadcast cellular signals inside the building. The systems usually use an external directional antenna to collect the best cellular signal, which is then transmitted to an amplifier unit which amplifies the signal, and retransmits it locally, providing significantly improved signal strength.

The more advanced models often also allow multiple cell phones to use the same repeater at the same time, so are suitable for commercial as well as home use.

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Yagi antenna will be mounted vertically at the roof top to the wall or pole such that it receives the maximum signal from the nearest base station and the channel to channel difference should be greater than 10db.

Booster should be protected from rain and moisture such that it can give maximum radiations to patch panel antenna. The working of patch panel antenna is to radiate the amplified signal to various mobile stations. Indoor antenna should be kept at the weak coverage areas. The bandwidth specifications should be taken care as specified above. For indoor purpose the gain should be not more the 70db, if gain exceeds the specifications it has to be controlled by Manual gain control (MGC) .Noise should be less than 6db.

II. METHODOLOGY

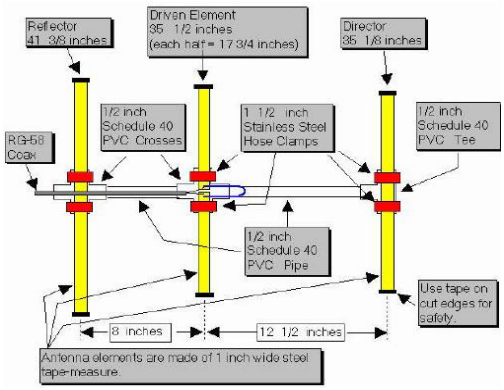
A.Different Operating Frequencies:

Repeaters are available for all the different GSM frequency bands, some repeaters will handle different types of network such as multi-mode GSM, DCS, 3G repeaters however dual band systems cost significantly more. Repeater systems are available for certain Satellite phone systems, allowing the satellite phones to be used indoors without a clear line of sigh t to the satellite. The frequency table for GSM, DCS, 3G:

S.No.	Frequency Band	Uplink Frequency(Mhz)	Downlink Frequency (Mhz)
1	Digital Communication System (GSM 1800)	1710-1785	1805-1880
2	3rd Generation (3G)	1920-1980	2110-2170

B.External directional antenna (Yagi Uda Antenna):

Although some of the less expensive models do not include an external directional antenna, they are crucial to providing significant signal strength gain. This is because the antenna can be oriented and located outside to provide the best possible signal, usually aligned with the nearest cell tower. Generally speaking the larger the external antenna the better the signal - although even a small, correctly oriented external antenna should provide better signal than the internal antenna on any cell phone. These can either be fitted by professionals or will include a signal strength monitor for easy alignment.



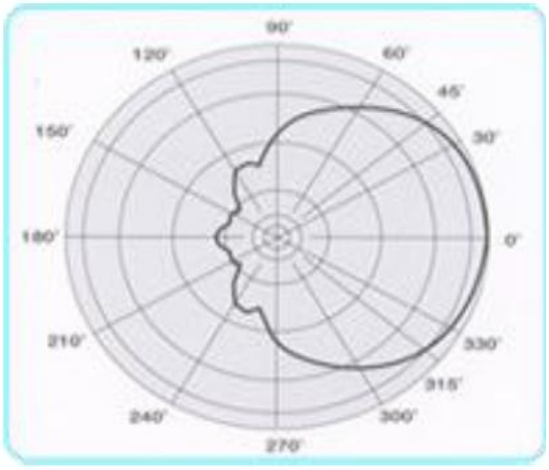
a. Design Specifications of the Yagi Antenna

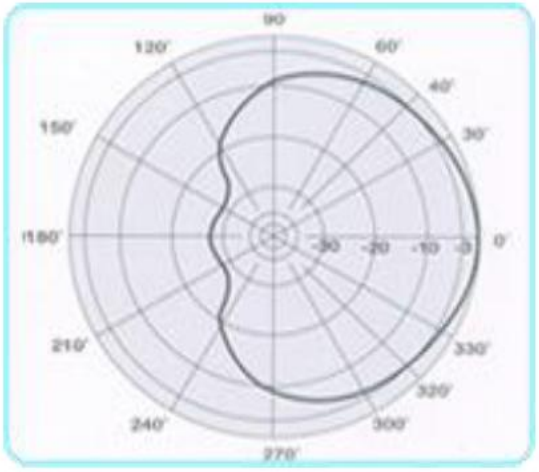
Frequency Range (in MHz)	800 ~ 960MHz / 1710 ~ 1900 MHz
Gain (dBi)	2 way / 3 way / 4 way
Impedance (in Ohms)	≤ 0.2/0.4/0.6 dB
VSWR	<1.3:1
Polarization	50 Ω
Horizontal Beam width	100 W
Vertical Beam width	N female
Power	100 W
Connector (female)	N Female
Weight (in gms)	750 / 1000
Lightning Protection/Ground Type	DC Ground/N (f)
Casing material	Brass

C. Internal rebroadcast antenna (Patch Panel Antenna):

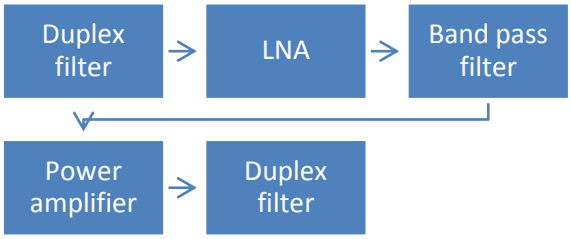
The better systems will generally include an internal monopole antenna (although the type of antenna is far from standardized) for rebroadcasting the signal internally - the advantage of using a monopole antenna is that the signal will be equally distributed in all directions (subject, of course, to attenuation from obstacles). Because all radio antennas are intrinsically polarized, cell phones perform best when their antennas are oriented parallel to the booster's antenna - although within reasonable proximity the booster's signal will be strong enough that the orientation of the cell phone's antenna will not make a significant difference in usability.

Radiation Pattern of Patch Panel Antenna:



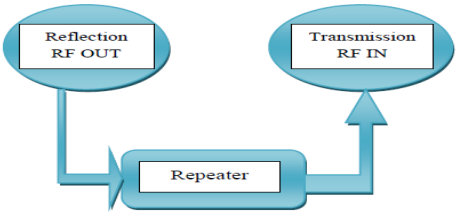


D. BI-DIRECTIONAL AMPLIFIER:

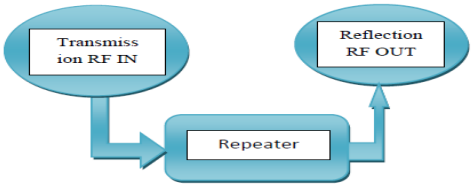


A basic Repeater mainly consists of Low noise Amplifier, Band Pass filter, Power Amplifier and Duplex filters. The signal from the Yagi Uda Antenna is sent to the Duplex filter and from the duplex filter it is sent to Low noise Amplifier module. Low noise amplifier as a module is made up of MGA 31589, Saw filters and ABA54563. These are the amplifiers which provide a sufficient amount of gain to the signal and are sent to the band pass filter. All these amplifiers are provided with biasing components which include capacitors and inductors. Attenuation pads are provided to get the required amount of gain at each and every stage. Signal from the Low Noise Amplifier (LNA) is sent to the Band Pass filter which selects the particular bandwidth in which the signal has to be amplified. The Bandwidth is selected as per the user requirement in the frequency bands (DCS, and 3G). This Required signal is sent to the Power amplifier module. This contains saw filters, ASL 19w and ABA54563, Amplifier which amplifies the signal in the required bandwidth. All the Amplifiers are provided with the required biasing components. The Amplified signal is given to the Duplex filter which separates out the low frequencies and high frequencies and is given to the Mobile Server. In Each and every module 220pf capacitors are placed in the RF path to block the DC voltage. When tested through a Network analyzer it should not receive any DC voltage hence the 220pf capacitors are placed in the RF path. The Repeater is supplied with a 5V power supply. Uplink and downlink frequency Response for DCS and 3G are tested in the network analyzer and the results obtained are mentioned below.

BLOCK DIAGRAM OF UPLINK



BLOCK DIAGRAM OF DOWNLINK



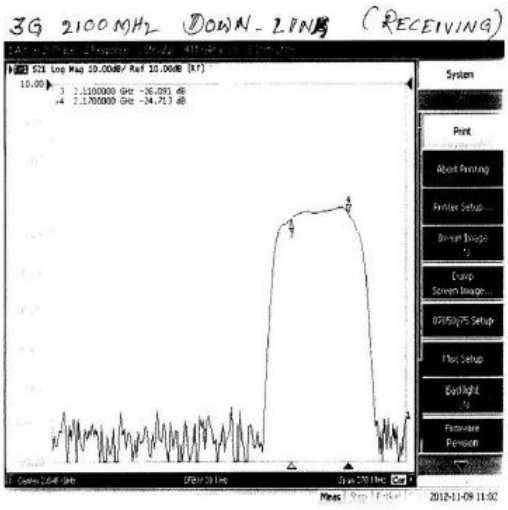
III. CELLULAR REPEATER INSTALLATION PROCEDURE

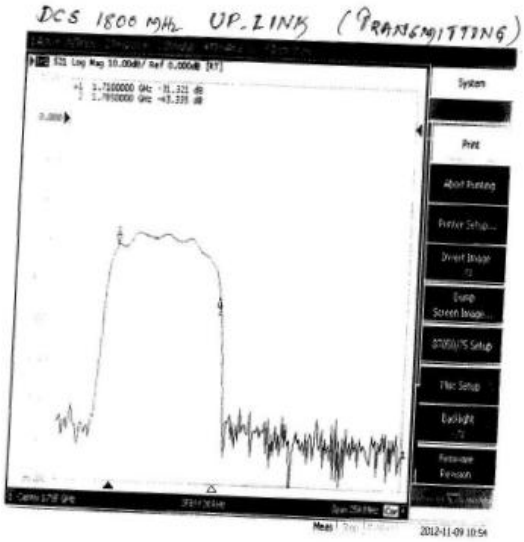
- Check Rx level, Receiving Quality and Ch to Ch power difference using cell phone, which has net monitor software. The following specifications have to be met at pick up point.
  - Rx level: -60±10dBm.
  - Receiving Quality: 0 to +3
  - Ch to Ch power difference : >7dB.
- If the above parameters do not meet; then change the pickup position, such that above specifications are met.
- Fix Yagi antenna in vertical orientation towards BTS direction, such that maximum Rx level is received.
- Connect one end of the RF cable to Yagi and other end to BTS/Yagi antenna port of the Booster. Ensure that connections are proper and effective.
- Locate convenient place for booster and fix it. If it is outdoor installation, ensure that booster is protected from rain.
- Fix the power cord to the booster and connect the PSU to the supply point.
- Fix Patch antenna in vertical position, where the boosted signal is required. Ensure that Patch antenna is fixed at least 2 meters away from the booster. Ensure that cables connected to the booster do not overlap each other.
- Minimize cable length to avoid cable loss.
- Switch on the booster. Adjust the manual gain control if required.
- Finally note down CID, CH & LAC.

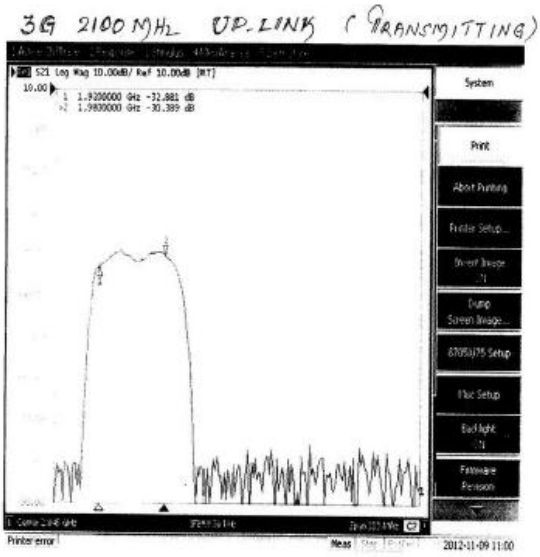
IV. SIMULATIONS AND DISCUSSIONS:

The Graphs mentioned below depict the gain obtained for uplink and downlink frequencies for the DCS and 3G frequency bands. The DCS and 3G are connected to a duplexer and we can operate all the two at a time or individually this depends upon the user requirement. All the two uplink frequencies can be observed at a time and similarly all the two downlink frequencies can be observed at a time on the network analyzer screen. We can also observe the increase in bandwidth as the frequency of operation increases. Hence when DCS and 3G are maintained at same gain we can observe that 3G has more bandwidth compared to DCS

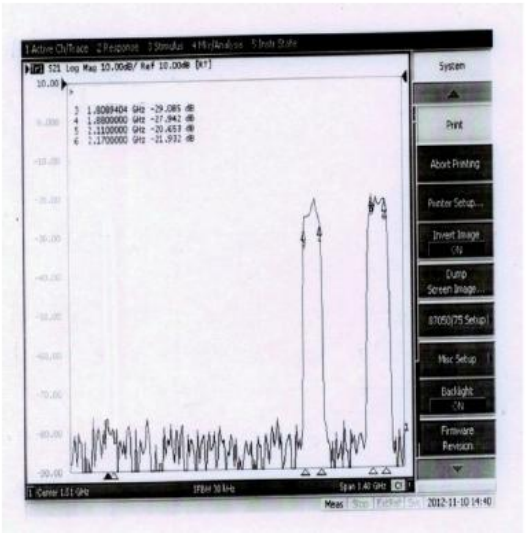
b. *3G 2100 MHz Frequency Response*



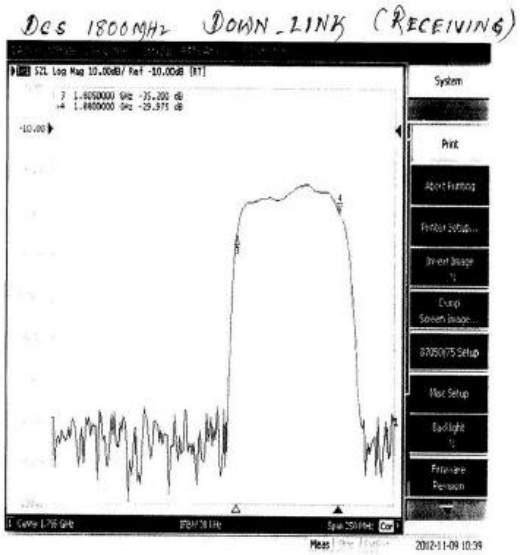


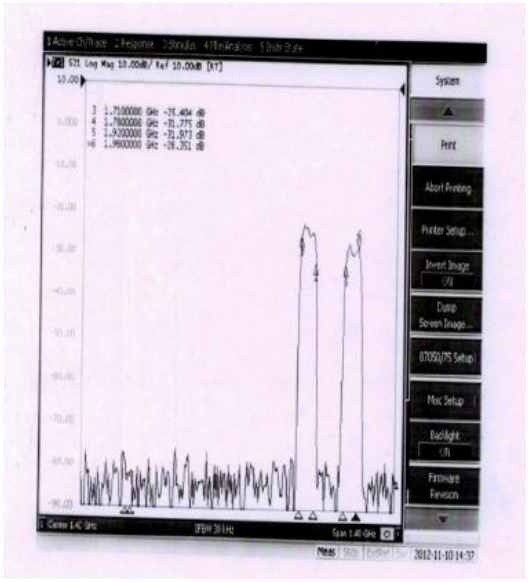


d.DUAL BAND (DCS, 3G) FREQUENCY RESPONSE



c. DCS 1800Mhz Frequency Response





a. *DCS UPLINK*

Gain : 58.679dB

Frequency Range: 1710MHz – 1785MHz

b. DCS DOWNLINK

Gain : 60.025dB
Frequency Range :1805MHz – 1880 MHz

c. 3G UPLINK

Gain: 59.611dB
Frequency Range :1920MHz – 1980MHz

d. 3G DOWNLINK

Gain : 65.287dB
Frequency Range :2110MHz – 2170MHz

a. Performance of 3G:

Variation of the signal strength before and after switching of the cellular repeater:

When the cellular repeater is in OFF state

DOWNLINK (Mb/s)	UPLINK (Mb/s)	LATENCY (ms)
0.56	0.14	68
0.71	0.59	68
0.81	0.2	69

When the cellular repeater is in ON state

DOWNLINK (Mb/s)	UPLINK (Mb/s)	LATENCY (ms)
1.92	1.79	62
2	2.02	58
2.51	2.18	62

If we observe from above table, the amplification of signal has been almost seven times the normal signal.

V. CALCULATION OF THE FINAL OUTPUT GAIN:

- By using the net monitor software the gain in the required channel and its neighbor channels can also be calculated.
- Using that process the signal gain in a particular channel is obtained.
- Then the gain of the External Directional antenna is added to that signal gain, to the resultant gain the return loss of the cable is added.
- To that gain the Internal Rebroadcast antenna gain is added.
- Finally the resultant gain gives the output gain with which the weaker signal is boosted to increase the signal service in the particular area.

VI. CONCLUSION:

We analyzed from our observations that signal can be enhanced in low coverage areas with the help of these boosters. We have observed the amplifications of 3G speed when booster is ON and OFF. Hence, practically also proved the importance of repeater in enhancing the signal. Finally, we conclude by saying that repeaters can improve the signal strength to such an extent that everyone can receive signals without having any disturbances.

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